ON SOME POINTS IN THE EARLY HISTORY OF ASTRONOMY.[1]

I.

IN the last astronomical course given in this theatre the subject touched upon was our present knowledge of the sun and stars. Some of you may possibly have been present at the lectures, but in any case the point made was something like this: an enormous advance had recently been made in our astronomical knowledge and in our powers of investigating the various bodies which people space, by the introduction of methods of work and ideas from other branches of science: the purpose was to show that the recent progress was to a large extent dependent upon the introduction of methods from other sciences.

The present course will also deal with the sun and stars, but the point of view will be changed. What I shall endeavour to do in the present course will be to show that a knowledge of even elementary astronomy may be of very great assistance to students of other branches of science; in other words, that astronomy is well able to pay her debt. Those branches to which I shall now chiefly refer are archæology, history, folk-lore, and all that learning which deals with man's first attempts to grasp the meaning and phenomena of the universe in which he found himself before any scientific methods were available to him, before he had any idea of the origins or the conditionings of the things around him. You can quite understand that for that we have to go a considerable distance back in time.

It seems to be generally accepted by archæologists that the first civilizations with which we are acquainted were those in the Nile valley and in the adjacent countries.

The information which we possess concerning these countries has been obtained from the remains of their cities, of their temples, even of their observatories and of the records of their observatories: of history on papyrus we have relatively little.

But when we come to the other two groups of nations to which I shall have to refer, China and India, there we have paper records; but, alas, no monuments of undoubtedly high antiquity. It is true that there are many monuments in India in the present day, but, on the authority of Prof. Max Müller, these monuments are relatively modern. We go back in Egypt to a period, as estimated by various authors, of something like 6000 or 7000 years; we go back in Babylonia certainly 4000 years; in China and in India we go back as certainly to more than 4000 years ago.

When one comes to examine the texts, whether written on papyrus, burnt in brick, or cut on stone, which archæologists have obtained from these sources, we at once realize that man's earliest observations of the heavenly bodies may very fairly be divided into three perfectly distinct stages; I do not mean to say that these stages follow each other exactly, but at one period one stage was more developed than another, and so on.

For instance, in the first stage, wonder and worship were the prevalent features; in the second, there was a desire to apply the observation of celestial phenomena in two directions, one the astrological direction, and the other, the direction of utility—for instance, the formation of a calendar and the foundation of years and months and days.

Only more recently—not at all apparently in the early stage—was any observation made of any celestial object for the mere purpose of getting knowledge. We know from the recent discoveries of Strassmaier and Epping that this stage was reached at Babylon at least 300 years B.C., at which period regular calculations were made of the *future* positions of moon and planets. This of course is now practically the only source of interest in astronomy to us: we no longer worship the sun; we no longer believe in astrology; we have our calendar; but we must have a nautical almanac calculated years beforehand, and some of us like to know a little about the universe which surrounds us.

It is very curious and interesting to know that this first stage, this stage of worship, is practically missing in the Chinese annals; the very earliest Chinese observations show us the Chinese, a thoroughly practical people, trying to get as much out of the stars as they could for their terrestrial purposes.

In Assyria and Babylonia it is a remarkable thing that from the beginning of things—so far as we can judge from the monuments—the sign for God was a star; and although the information is perhaps not so precise as in the case of Egypt, yet no doubt in Babylonia the worship stage existed in equal activity.

We may take the Vedas to bring before us the remnants of the first ideas which dawned upon the minds of the earliest dwellers in Western Asia—that is, the territory comprised between the Mediterranean, the Black Sea, the Caucasus, the Caspian Sea, the Indus, and the waters which bound the southern coasts, say, as far as Cape Comorin. Of these populations, probably the Chaldæans may be reckoned as being the first. According to Lenormant—and he is followed by all the best scholars—this region was invaded in the earliest times by peoples coming from the steppes of Northern Asia. Bit by bit they spread to the west and east. There are strange variants in the ideas of the Chaldæans recovered from the monuments and those preserved in the Vedas. Nevertheless, we find a sun-god—Utu, Babbar[1]—and the following hymn:—

> "Oh Sun, in the most profound heaven thou shinest. Thou openest the locks which close the high heavens. Thou openest the door of heaven. Oh Sun, towards the surface of the earth thou turnest thy face. Oh Sun, thou spreadest above the surface, like a mantle, the splendour of heaven."

The earth to these peoples was a round boat, bottom-uppermost, surrounded on all sides by ocean (Apsu) near the edge; on the edge itself rested the hemispherical sky (Anna). As the sky thus rested on the earth, the earth rested on an abyss, the home of death and darkness.

Let us consider for a moment what were the first conditions under which the stars and the sun would be observed. There was no knowledge, but we can very well understand that there was much awe, and fear, and wonder. Man then possessed no instruments, and the eyes and the minds of the early observers were absolutely untrained. Further, night to them seemed almost death, no man could work; for them, there was no electric light, to say nothing of candles, so that in the absence of the moon the night reigned like death over every land. There is no necessity for us to go far into this matter by trying to put ourselves into the places of these early peoples; we have only to look at the records: they speak very clearly for themselves.

Let us begin with India, whence the first complete revelations of this kind came. Max Müller and others during recent years have brought before us an immense amount of most interesting information, some of which I hope now is to be found in our free libraries.

They tell us that 1500 years B.C. there was a ritual, a set of hymns called the Veda (Veda meaning knowledge).

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[1] From shorthand notes of a course of lectures to working men delivered at the Museum of Practical Geology, Jermyn Street, in November 1890. The notes were revised by me at Aswan during the month of January. I have found, since my return from Egypt in March, that part of the subject-matter of the lectures has been previously discussed by Herr Nissen, who has employed the same materials as myself. To him, therefore, so far as I at present know, belongs the credit of having first made the suggestion that ancient temples were oriented on an astronomical basis. His article is to be found in the *Rheinisches Museum für Philologie*, 1885.

[1] Maspéro, "Histoire ancienne des Peuples de l'Orient," p. 136.

These hymns were written in Sanskrit, which a few years ago was almost an unknown language; we know now that it turns out to be the nearest relation to our English tongue. The thoughts and feelings expressed in these early hymns contain the first roots and germs of that intellectual growth which connects our own generation with the ancestors of the Aryan races; "those very people who, as we now learn from the Vedas, at the rising and the setting of the sun listened with trembling hearts to the sacred songs chanted by their priests. The Veda, in fact, is the oldest book in which we can study the first beginnings of our language and of everything which is embodied in all the languages under the sun." The oldest, most primitive, most simple form of Aryan Nature-worship finds expression in this wonderful hymnal, which doubtless brings before us the rituals of the ancient Aryan populations represented also by the Medes and Persians. There was, however, another branch, represented by the Zend-Avesta, as opposed to the Vedas, among whom there was a more or less conscious opposition to the gods of Nature, to which we are about to refer, and a striving after a more spiritual deity, proclaimed by Zoroaster under the name of Ahura-Mazda, or Ormuzd. The existence of these rituals side by side in time tends to throw back the origin of the Nature-worship of both. Now, what do we find? In the Veda the gods are called Devas, a word which means bright; brightness or light being one of the most general attributes shared by the various manifestations of the deity. What were the deities? The sun, the sky, the dawn, fire, and storm. It is clear, in fact, from the Vedas that sunrise was, to those from whom the ritual had been derived, the great revelation of Nature, and in time in the minds of the poets of the Veda, "deva," from meaning "bright," gradually came to mean "divine." Sunrise it was that inspired the first prayers of our race, and called forth the first sacrificial flames. Here, for instance, is an extract from one of the Vedas. "Will the sun rise again? Will our old friend the Dawn come back again? Will the power of Darkness be conquered by the God of Light?"

These three questions in one hymn will show what a questionable stage in man's history is thus brought before us. We find very many names for Sun-gods—

Mitra,
Indra (the day brought by the sun),
Sûrya,
Vasishtha,
Arusha (bright or red);

and for the Dawn-gods—

Ushas,
Dyaus,
Dyotanâ,
Ahanâ,
Urvasi,

We have only to consider how tremendously important must have been the coming of the sun in the morning, bringing everything with it, and the dying away of the sun in the evening, followed at once by semi-tropical quick darkness, to cease to wonder at such worship as this. Here is an extract from one hymn to the Dawn (Ushas):—

> (1) She shines upon us like a young wife rousing every living being to go to his work; when the fire had to be kindled by men she made the light by striking down darkness.
>
> (2) She rose up spreading far and wide, and moving everywhere, she grew in brightness, wearing her brilliant garment [the mother of the cows (the mornings)], the leader of the days, she shone gold-coloured, lovely to behold.
>
> (3) She, the fortunate, who brings the eye of the gods, who leads the white and lovely steed (of the sun), the *Dawn*, was seen revealed by her rays, with brilliant treasures, following everyone.
>
> (4) Thou art a blessing when thou art near. . . . Raise up wealth to the worshipper, thou mighty *Dawn*.
>
> (5) Shine for us with thy best rays, thou bright Dawn. . . .
>
> (6) Thou daughter of the sky, thou high-born Dawn. . . .

In addition to the Sun and the Dawn, which turn out to be the two great deities in the early Indian Pantheon, other gods are to be met with, such as Prithivî, the Earth on which we dwell; Varuna, the Sky; Ap, the Waters; Agni, the Fire; and Maruts, the Storm-gods. Of these, Varuna is especially interesting to us. We read:—

> "Varuna stemmed asunder the wide firmament; he lifted up on high the bright and glorious heaven; he stretched out apart the starry sky and the earth."

Again—

> "This earth, too, belongs to Varuna, the king, and this wide sky with its ends far apart. The two seas (the sky and the ocean) are Varuna's loins."

Finally, the result of all this astral worship was to give an idea of the connection between the earth and the sun and the heavens, which are illustrated in later Indian pictures, which bring before us modernized and much more concrete views of these early notions, ultimately transformed into this piece of poetic thought—that the earth was a shell supported by elephants which represent strength, the elephants being supported on a tortoise which represents infinite slowness.

This poetical view subsequently gave way to one less poetical—namely, that the earth was supported by pillars; on what the pillars rested is not stated, and it does not matter. We must not consider this as ridiculous, and pardonable merely because it is so early in point of time, because, coming to the time of Greek civilization, Anaximander told us that the earth was cylindrical in shape, and every place that was then known was situated on the flat end of the cylinder; and Plato, on the ground that the cube was the most perfect geometrical figure, imagined the earth to be a cube, the part of the earth known to the Greeks being on the upper surface. In these matters, indeed, the vaunted Greek mind was little in advance of the predecessors of the Vedic priests.

We now turn to Egypt. Here, as I have said, the main source of information consists no longer in writings like the Vedas, but in the inscriptions on the monuments. It is true that, in addition to the monuments, we have the Book of the Dead, and certain records found in tombs; but, in the main, the source of information which has been most largely drawn upon consists in the monuments themselves.

It has been impossible, up to the present time, to fix with very great accuracy the date of the earliest monuments. If any of you will get from your public libraries any books on Egypt, I am sure you will feel that it is not a question of knowing so little—it is a question of knowing anything at all. When one considers that at the beginning of this century not a sign on any of these monuments was understood, and that now the wonderful genius of a small number of students has enabled Egyptologists to read the inscriptions with almost as much ease and certainty as we read our morning papers; *this* is what is surprising, and not the fact that we as yet know so little, and in many cases lack certainty.

I have told you that probably some of these monuments are 6000 or 7000 years old. How has this been determined? One of the many points investigated by Egyptologists has been the chronology of the kings of Egypt from their first king, whom all students recognize as Mena or Menes. All these students have come to the definite conclusion that there was a King Menes, and that he reigned a long time ago; but with all their skill the total result is that they cannot agree to the date of this king within a thousand years, for the reason that in these early days astronomy was a science still to be cultivated, and therefore the early Egyptians had not a perfect mode of recording; they had no idea of a hundred years as we have. All their reckonings were the reckonings of the reigns of kings. We now, fortunately for us, have a calendar which enables us to deal with large intervals of time, but still we reckon, in Egyptian fashion, by the reigns of kings in our Acts of Parliament. Furthermore, Egypt being then a country liable to devastating wars, and to the temporary supremacy of different kingly tribes, it has been very difficult to disentangle the various lists of kings so as to obtain one chronological line, for the reason that sometimes there were lines of kings existing together in different regions. The latest date for King Menes is, according to Bunsen, 3600 years B.C.; the earliest date, assigned by Boeckh, 5702 years B.C.; Unger, Brugsch, and Lepsius give, respectively, 5613, 4455, 3892. For our purpose we will call the date 4000 B.C.—that is, 6000 years ago.

We come now to deal with the ideas of the early inhabitants of the Nile valley. We find that in Egypt, as in India, we are in presence absolutely of the worship of the Sun and of the accompanying Dawn. The early Egyptians, whether they were separate from, or more or less allied in their origin to, the early Chaldæans, had exactly the same view of Nature-worship as the others had, and we find in their hymns and the lists of their gods that the Dawn and the Sunrise were the great revelations of Nature, and the things which were most important to man; *and therefore everything connected with the Sunrise and the Dawn was worshipped.*

Renouf, one of the most competent of living writers on these subjects, says: "I fear Egyptologists will soon be accused, like other persons, of seeing the dawn everywhere," and he quotes with approbation, and applies to his own subject, the following passage from Max Müller relating to the Veda:—

> "I look upon the sunrise and sunset, on the daily return of day and night, on the battle between light and darkness, on the whole solar drama in all its details, that is acted every day, every month, every year, in heaven and in earth, as the principal subject."

Among the names given by the Egyptians to the sun are:—

Hor, or Horus.
Chepera (morning sun).
Rā (noon).
Tmu (evening sun).
Osiris (sun when set).

The phenomena of morning and evening twilight gave rise to the following divinities:—

Isis represents the Dawn and the Twilight; she prepares the way for the Sun-god. The rising sun between Isis and Nephthys = morning.

Nephthys is the Dawn and the Twilight, sometimes Sunset.

Shu is also the Dawn, or sunlight. Tefnut represents the coloured rays at dawn. Shu and Tefnut are the eyes of Horus. Shu was also called "Neshem," which means green felspar, in consequence of the green colour observed at dawn. The green tint at dawn and sunset are represented further by the "sycamore of emerald." Sechet is another goddess of the Dawn, the fiery Dawn.

The *red* colours at sunset were said to be caused by the blood flowing from the Sun-god when he hastens to his suicide. A legend describes Isis as stanching the blood flowing from the wound inflicted on Horus by Set.

Hathor is, according to Budge, identified with Nu or Nut, the sky, or place in which she brought forth and suckled Horus. She is the female power of Nature, and has some of the attributes of Isis, Nut, and Maāt.

I have not time to quote the many hymns to the Sun-gods which have been recovered from the inscriptions, but the following extracts will show that the worship was in the main at sunrise or sunset—in other words, that the *horizon* was in question:—

> "Thou disk of the Sun, thou living God! There is none other beside thee. Thou givest health to the eyes through thy beams, Creator of all beings. *Thou goest up on the eastern horizon of the heaven* to dispense life to all which thou hast created—to man, four-footed beasts, birds, and all manner of creeping things on the earth where they live. Thus they behold thee, and they go to sleep when thou settest."

Hymn to Tmu—

> "Come to me, O thou Sun,
> Horus of the horizon, give me help."

Hymn to Horus—

> "O Horus of the horizon, there is none other beside thee,
> Protector of millions, deliverer of tens of thousands."

Hymn to Ra-Tmu-Horus—

> "Hail to thee of the double horizon, the one god living by Maat. . . . I am the maker of heaven and of the mysteries of the twofold horizon."

Hymn to Osiris—

> "O Osiris! Thou art the youth *at the horizon* of heaven daily, and thine old age at the beginning of all seasons. . . .
>
> "The *ever-moving* stars are under obedience to him, and so are *the stars which set.*"

Hymn to Ra—

> "O Ra! in thine egg, radiant in thy disk, shining forth from the horizon, swimming over the steel (?) firmament.
>
> "Tmu and Horus of the horizon pay homage to thee (Amon-Ra) in all their words."

We next have to gain some general idea of the Egyptian cosmogony—the relation of the sun and dawn to the sky; this is very different from the Indian view. The Sky is Nu (Fig. 1), represented as a female figure bending over Seb, the Earth, with her feet on one and her finger-tips on the other horizon. The Sun-gods, and even the stars, were supposed to travel in boats across the firmament from one horizon to the other. The underworld was the abode of the dead, and daily the sun and the stars which set died on passing to the regions of the west, or Amenti, below the western horizon, to be born again on the eastern horizon on the morrow. In this we have the germ of the Egyptian idea of immortality.

Among other gods which may be mentioned are Chnemu, the "Moulder," who was thought to possess some of the attributes of Rā; and Patah (or Ptah), the "Opener," who is at times represented with Isis and Nephthys, and then appears as a form of Osiris.

We can now begin to glimpse the Egyptian mythology.

Seb, the Earth, was the husband of Nut, the Sky; and the Sun- and Dawn-gods and goddesses were their children, as also were Shu, representing sunlight, and Tefnut, representing the flames of dawn.

Maāt, the goddess of law, was the daughter of Ra.

When one comes to consider the Rig-Veda and the Egyptian monuments from an astronomical point of view, one is struck by the fact that the early worship and all the early observations related to the horizon. This was true not only for the sun, with which so far we have exclusively dealt, but it was equally true of the stars which studded the general expanse of sky.

We must be perfectly clear before we go further what this horizon really is, and for this some diagrams are necessary.

The horizon of any place is the circle which bounds our view of the earth's surface, along which the land (or sea) and sky appear to meet. We have to consider the relation of the horizon of any place to the apparent movements of celestial bodies at that place.

We know, by means of the demonstration afforded by Foucault's pendulum, that the earth rotates on its axis, but this idea was of course quite foreign to these early peoples. Since the earth rotates with stars, infinitely removed, surrounding it on all sides, the apparent movements of the stars will depend very much upon the position we happen to occupy on the earth: this can be made quite clear by these diagrams. An observer at the North Pole of the earth, for instance, would see the stars moving round in circles parallel to the horizon. No star would either rise or set—one half of the heavens would be always visible above his horizon, and the other half invisible; whereas an observer at the South Pole would see that half of the stars invisible to the observer at the northern one, because it was the half below his horizon. If the observer be on the equator, the movements of the stars will appear to be as indicated in this diagram (Fig. 3)—that is, all the stars will rise and set, and each star in turn will be half its time above the horizon, and half its time below it. But if we consider the position of an observer in middle latitude, say in London, we find that some stars will always be above the horizon, some always below—that is, they will neither rise nor set. All other stars will both rise and set, but some of them will be above the horizon for a long time and below for a short time, whereas others will be a very short time above the horizon and a long time below it.

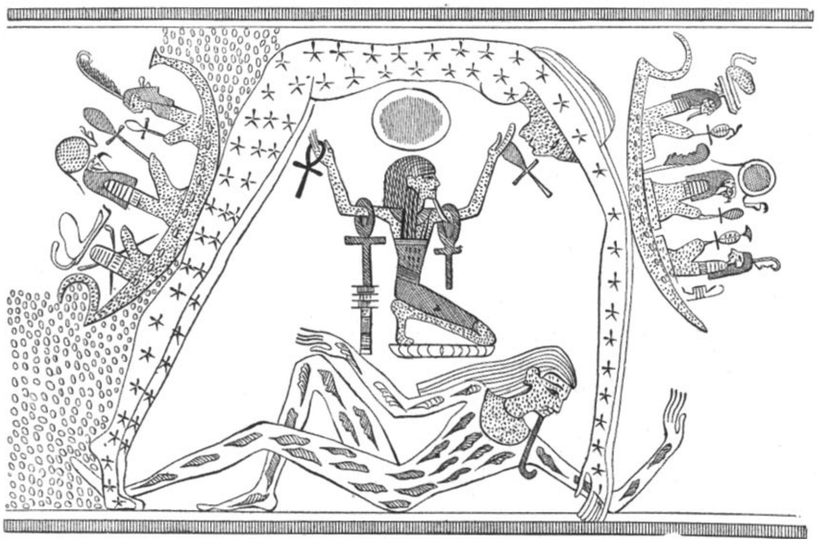

Fig. 1.—Egyptian representation of the Earth (Seb), a recumbent figure; with Nu stretching over the Earth from horizon to horizon, and the boats of the Sun-gods floating over her.

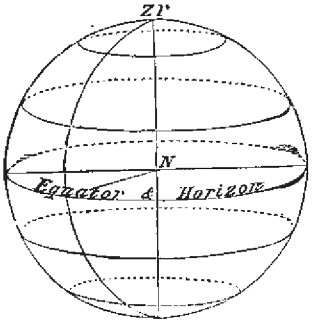

Fig. 2.—The celestial sphere, as viewed from the North Pole. A parallel sphere.

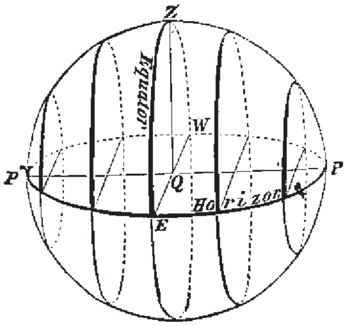

Fig. 3.—The celestial sphere, as viewed from the Equator. A right sphere.

Wherever we are upon the earth we always imagine that we are on the top of it. The idea held by all the early peoples was that the earth was an extended plain: they imagined that the land that they knew and just the surrounding lands were really in the centre of the extended plain. Plato, for instance, was content to put the Mediterranean and Greece upon the top of his cube, and Anaximander placed the same region at the top of his cylinder.

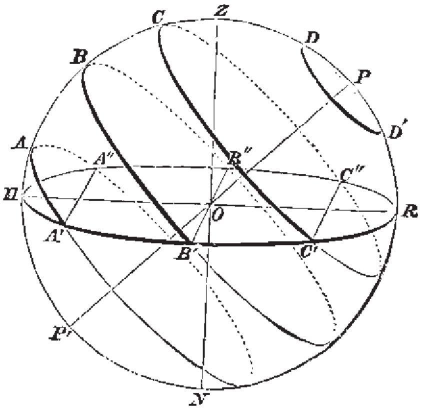

Fig. 4.—The celestial sphere, viewed from a middle latitude. An oblique sphere. In this woodcut DD′ shows the apparent path of a circumpolar star; BB′B″ the path and rising and setting points of an equatorial star; CC′C″ and AA′A″ those of stars of mid declination, one north and the other south.

By the use of the globe we can best study the conditions of observation at the poles of the earth, the equator, and some place in middle latitude. The wooden horizon of the globe is parallel to the horizon of a place at the top of the globe, which horizon we can represent by a wafer. In this way we can get a very concrete idea of the different relations of the observer's horizon to the apparent paths of the stars in different latitudes.

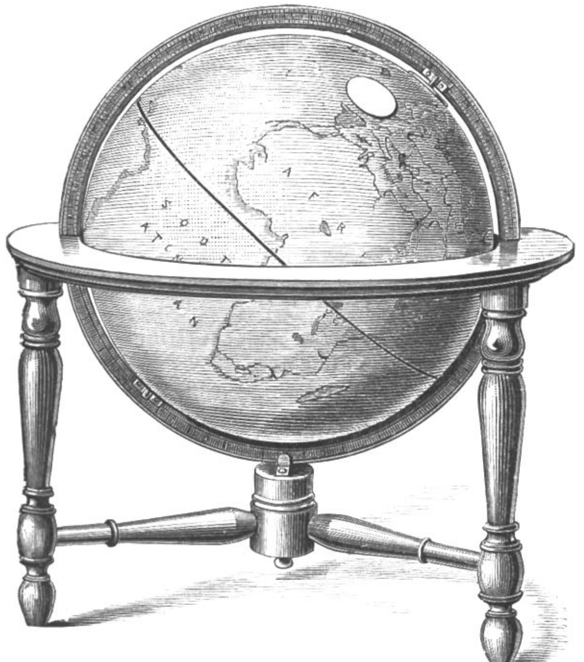

FIG. 5.—Diagram to show how the inclination of the horizon of London will change with the rotation of the Earth.

J. NORMAN LOCKYER.

(*To be continued.*)

ADDITIONAL RESULTS OF THE UNITED STATES SCIENTIFIC EXPEDITION TO WEST AFRICA.

WRITING a year ago from Ascension Island, I gave to NATURE a partial account of the work of the Expedition from October 1889 to March 1890. Subsequently the U.S.S. *Pensacola*, Captain A. R. Yates, U.S. Navy, commanding, arrived at Barbados on April 28, at Bermuda on May 18, and terminated her cruise with the Expedition on reaching New York on the 23rd of the same month.

My previous communication to NATURE (vol. xlii. p. 8), relates the great obligation of the Expedition to His Excellency Governor Sir H. B. Loch, and to Dr. David Gill, H.M. Astronomer at Cape Town, to His Excellency Governor Antrobus, at Saint Helena, and to Captain Napier, R.N., then in charge of Ascension, acting in accordance with the very liberal instructions of the Admiralty. Although our arrival at Barbados was entirely unexpected, all necessary facilities were at once provided by direction of His Excellency Governor Sir Walter Sendall.

The gravity and magnetic work at Bridgetown occupied nearly a fortnight. Mr. E. D. Preston, in special charge of this department of the Expedition, occupied in all fourteen magnetic stations, of which five were on the West Coast of Africa, and eight on islands of the North and South Atlantic. The area of the gravity stations extends from Cape Town to Washington, covering a range of 73° in latitude, and 96° in longitude. The elevations of these stations range from 7 feet to 2250 feet above sea-level. These observations are now in progress of reduction by Mr. Preston, under the direction of Prof. Mendenhall, Superintendent of the U.S. Coast and Geodetic Survey; and the definitive results will, it is hoped, be available at the conclusion of the present year. "Whether," says Mr. Preston, "they show the Atlantic islands to be heavy or light as compared with the continental masses, they will at least add considerable new material for the determination of the earth's figure."

By direction of the Hon. Secretary of War, and General Greely, Chief Signal Officer of the Army, Prof. Cleveland Abbe was detailed as meteorologist of the Expedition. His observations and researches, assiduously conducted during the entire cruise of the *Pensacola*, are so significant that no brief statement can do them full justice. From the forthcoming Report of the Expedition I excerpt the following sections of Prof. Abbe's preliminary report:—

(1) I should mention at the outset that the work with small balloons was carried on sufficiently to demonstrate the practicability of this method of getting the actual velocity of the wind; but, by the advice of the maker of the balloons, I had omitted taking up with me the varnish ordinarily used, as being probably unnecessary and possibly dangerous to manipulate on ship-board. The result was that I found it would become necessary to use more balloons than originally contemplated. Still I deem it a decided gain to have been able to make enough observations to show that the method of determining the velocity of the wind by small balloons is accurate and practicable, both on land and sea, and but little, if at all, more expensive than the use of self-recording anemometers.

(2) The mirror nephoscope used by me rested on the Ritchie liquid compass (U.S. Navy standard), which was established on the after-bridge, and which compass I was free to use at all times. Although free in its gimbals, yet the compass is by no means exactly horizontal; so that more numerous observations must be made at sea than on land, if the same resulting accuracy is desired. I was able to maintain daily observations, and I can but consider that the opportunity thus offered me has been entirely unique in the history of meteorology; and unless I am greatly mistaken in my knowledge of the literature of the subject, it will be found that the results attained will form a valuable basis for further study. My observations have in fact led to some change in my own views as to the general circulation of the atmosphere, and every form of fluid motion has been found by me to be visibly illustrated in the cloud-structure.

(3) I have attempted a simple and rational classification of clouds, based, not on shapes and appearances, but primarily on their modes of formation.

(4) A method of using the nephoscope has been elaborated for the determination of actual heights and velocities of clouds (or balloons) by combining observations made when the observer is moving successively in two different directions, or with two different velocities. The instrument can be used in a waggon, or car, or boat. I call this "*the aberration method*," as distinguished from ordinary parallax methods.

(5) My work shows that the observed movements of the clouds and the wind have such a relation to the presence of a storm centre, an island, or to any other disturbance, that one should be able to locate the position of such a disturbance by observations made at one locality.

(6) At Fayal, on the summit of Pico, I first observed the formation of a cloud, with which I afterwards became